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Applicant: S. IKEDA, et al.

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Title: X-RAY IMAGE DIAGNOSTIC APPARATUS

Group: 2882

Examiner: Jurie YUN

Confirmation No.: 1231

AMENDMENT

Mail Stop: Amendment (Fee)
Commissioner for Patents
P.O. Box 1450
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June 13, 2007

Sir:

In response to the Office Action dated March 13, 2007, please amend the above-identified application as listed below and as set forth on the following pages:

Amendments to the Claims

Remarks are included following the amendments.

Amendments to the Claims

The following listing of claims replaces all prior listings, and all prior versions, of claims in the application.

Listing of Claims

1. (Currently amended) An X-ray image diagnostic apparatus, characterized by comprising:

an X-ray source that irradiates X-rays to a subject;

an X-ray flat panel detector that is provided oppositely to the X-ray source and detects transmitted X-rays from the subject as an X-ray image;

image processing means for applying image processing to the X-ray image detected by the X-ray flat panel detector; and

image display means for displaying the X-ray image having undergone the image processing in the image processing means,

wherein the image processing means includes:

storage means for storing plural sets of residual image data that attenuate with time, acquired in advance from X-ray images in X-ray image acquisition modes from the X-ray flat panel detector before an actual measurement, in correspondence with the X-ray image acquisition modes;

~~and~~

~~residual image correction means for correcting residual image data contained in an X-ray image in the actual measurement from the X-ray flat panel detector, using the residual image data stored in the storage means~~

an image memory that stores one frame of the residual image data, which is obtained in a fluoroscopic mode after X-ray irradiation ends in the

radiographic mode and before X-ray irradiation starts by switching to the fluoroscopic mode, from the X-ray flat panel detector;

a computing unit that reads out quantities of attenuation of the first and subsequent frames of the residual image data in response to time on a basis of one frame of the residual image data stored in the image memory, and subtracts the read quantities of attenuation of the residual image data from a signal outputted from the X-ray flat panel detector; and

a control portion that controls the image memory, a attenuation quantity storage portion, and the computing unit on a basis of respective signals, including control signals for each of the X-ray image acquisition modes including a radiographic signal and a fluoroscopic signal, and an image synchronizing signal to enable a display on the display means.

2. (Cancelled)

3. (Original) The X-ray image diagnostic apparatus according to Claim 1, wherein:

the storage means stores plural frames of images of a residual image while X-rays are shielded after an X-ray image is acquired at a specific X-ray dose in advance.

4. (Original) The X-ray image diagnostic apparatus according to Claim 1, wherein the image processing means includes:

plural image memories, each of which stores one frame of residual image data from the X-ray flat panel detector;

plural attenuation quantity storage portions that store quantities of attenuation of first and subsequent frames of the residual image data read out from the image memories;

a weight addition quantity storage portion that reads out quantities of attenuation of the first and subsequent frames of the residual image data in response to a time on the basis of one frame of the residual image data stored in each of the image memories, subjects the read quantities of attenuation of residual images to weighting addition depending on magnitude of a quantity of remaining residual images, and stores weight addition quantities;

a computing unit that reads out the weight addition quantities stored in the weight addition quantity storage portion in response to a time, and subtracts the read weight addition quantities from a signal outputted from the X-ray flat panel detector; and

a control portion that controls the image memories, the attenuation quantity storage portions, and the weight addition quantity storage portion on the basis of respective signals, including control signals for each of the X-ray image acquisition modes including a radiographic signal and a fluoroscopic signal, and an image synchronizing signal to enable a display on the display means.

5. (Original) The X-ray image diagnostic apparatus according to Claim 1, wherein the image processing portion includes:

an image memory that stores one frame of residual image data from the X-ray flat panel detector;

a first switch that switches an output of a quantity attenuation of an image of a residual image read out from the image memory depending on a read pixel matrix of the X-ray flat panel detector;

plural attenuation quantity storage portions, each of which stores quantities of attenuation of first and subsequent frames of the residual image data on the basis of one frame from the image memory switched by the first switch, in correspondence with the read pixel matrix of the X-ray flat panel detector;

a second switch that reads out a quantity of attenuation of a residual image stored in the attenuation quantity storage portions in response to a time, and makes a switch to the read quantity of attenuation of the residual image data;

a computing unit that subtracts the quantity of attenuation of the residual image data switched by the second switch from a signal outputted from the X-ray flat panel detector; and

a control portion that controls the image memory, the attenuation quantity storage portions, and the first and second switches on the basis of respective signals, including control signals for each of the X-ray image acquisition modes including a radiographic signal and a fluoroscopic signal, and an image synchronizing signal to enable a display on the display means.

6. (Original) The X-ray image diagnostic apparatus according to Claim 1, wherein the image processing means includes:

an image memory that stores one frame of residual image data from the X-ray flat panel detector;

a first switch that switches an output of a quantity of attenuation of a residual image read out from the image memory depending on whether the X-ray image acquisition mode is a single radiographic mode or a continuous radiographic mode;

plural attenuation quantity storage portions, each of which stores quantities of attenuation of first and subsequent frames of the residual image data on the basis of one frame from the image memory switched by the first switch, in correspondence with the single radiographic mode and the continuous radiographic mode;

a second switch that reads out a quantity of attenuation of the residual image stored in the attenuation quantity storage portions in response to a time depending on the single radiographic mode or the continuous radiographic mode, and makes a switch to the read quantity of attenuation of the residual image;

a computing unit that subtracts the quantity of attenuation of the residual image switched by the second switch from a signal outputted from the X-ray flat panel detector; and

a control portion that controls the image memory, the attenuation quantity storage portions, and the first and second switches on the basis of respective signals, including control signals for each of the X-ray image acquisition modes including a radiographic signal and a fluoroscopic signal, and an image synchronizing signal to enable a display on the display means.

7. (Original) The X-ray image diagnostic apparatus according to Claim 6, wherein:

the control portion determines a quantity of the residual image generated from continuous exposures in response to an exposure time in the continuous radiographic mode.

8. (new) An X-ray image diagnostic apparatus, characterized by comprising:

an X-ray source that irradiates X-rays to a subject;

an X-ray flat panel detector that is provided oppositely to the X-ray source and detects transmitted X-rays from the subject as an X-ray image;

image processing means for applying image processing to the X-ray image detected by the X-ray flat panel detector; and

image display means for displaying the X-ray image having undergone the image processing in the image processing means,

wherein the image processing means includes:

storage means for storing plural sets of residual image data, acquired in advance from X-ray images in X-ray image acquisition modes from the X-ray flat panel detector before an actual measurement, in correspondence with the X-ray image acquisition modes; and

residual image correction means for correcting residual image data contained in an X-ray image in the actual measurement from the X-ray flat panel detector, using the residual image data stored in the storage means; and

plural image memories, each of which stores one frame of residual image data from the X-ray flat panel detector;

plural attenuation quantity storage portions that store quantities of attenuation of first and subsequent frames of the residual image data read out from the image memories;

a weight addition quantity storage portion that reads out quantities of attenuation of the first and subsequent frames of the residual image data in response to a time on the basis of one frame of the residual image data stored in each of the image memories, subjects the read quantities of attenuation of residual images to weighting addition depending on magnitude of a quantity of remaining residual images, and stores weight addition quantities;

a computing unit that reads out the weight addition quantities stored in the weight addition quantity storage portion in response to a time, and subtracts the read weight addition quantities from a signal outputted from the X-ray flat panel detector; and

a control portion that controls the image memories, the attenuation quantity storage portions, and the weight addition quantity storage portion on the basis of respective signals, including control signals for each of the X-ray image acquisition modes including a radiographic signal and a fluoroscopic signal, and an image synchronizing signal to enable a display on the display means.

9. (new) An X-ray image diagnostic apparatus, characterized by comprising:

an X-ray source that irradiates X-rays to a subject;

an X-ray flat panel detector that is provided oppositely to the X-ray source and detects transmitted X-rays from the subject as an X-ray image;

image processing means for applying image processing to the X-ray image detected by the X-ray flat panel detector; and

image display means for displaying the X-ray image having undergone the image processing in the image processing means,

wherein the image processing means includes:

storage means for storing plural sets of residual image data, acquired in advance from X-ray images in X-ray image acquisition modes from the X-ray flat panel detector before an actual measurement, in correspondence with the X-ray image acquisition modes; and

residual image correction means for correcting residual image data contained in an X-ray image in the actual measurement from the X-ray flat panel detector, using the residual image data stored in the storage means; and

an image memory that stores one frame of residual image data from the X-ray flat panel detector;

a first switch that switches an output of a quantity attenuation of an image of a residual image read out from the image memory depending on a read pixel matrix of the X-ray flat panel detector;

plural attenuation quantity storage portions, each of which stores quantities of attenuation of first and subsequent frames of the residual image data on the basis of one frame from the image memory switched by the first switch, in correspondence with the read pixel matrix of the X-ray flat panel detector;

a second switch that reads out a quantity of attenuation of a residual image stored in the attenuation quantity storage portions in response to a time, and makes a switch to the read quantity of attenuation of the residual image data;

a computing unit that subtracts the quantity of attenuation of the residual image data switched by the second switch from a signal outputted from the X-ray flat panel detector; and

a control portion that controls the image memory, the attenuation quantity storage portions, and the first and second switches on the basis of respective signals, including control signals for each of the X-ray image acquisition modes including a radiographic signal and a fluoroscopic signal, and an image synchronizing signal to enable a display on the display means.

10. (new) An X-ray image diagnostic apparatus, characterized by comprising:

an X-ray source that irradiates X-rays to a subject;

an X-ray flat panel detector that is provided oppositely to the X-ray source and detects transmitted X-rays from the subject as an X-ray image;

image processing means for applying image processing to the X-ray image detected by the X-ray flat panel detector; and

image display means for displaying the X-ray image having undergone the image processing in the image processing means,

wherein the image processing means includes:

storage means for storing plural sets of residual image data, acquired in advance from X-ray images in X-ray image acquisition modes from the X-

ray flat panel detector before an actual measurement, in correspondence with the X-ray image acquisition modes; and

residual image correction means for correcting residual image data contained in an X-ray image in the actual measurement from the X-ray flat panel detector, using the residual image data stored in the storage means; and

an image memory that stores one frame of residual image data from the X-ray flat panel detector;

a first switch that switches an output of a quantity of attenuation of a residual image read out from the image memory depending on whether the X-ray image acquisition mode is a single radiographic mode or a continuous radiographic mode;

plural attenuation quantity storage portions, each of which stores quantities of attenuation of first and subsequent frames of the residual image data on the basis of one frame from the image memory switched by the first switch, in correspondence with the single radiographic mode and the continuous radiographic mode;

a second switch that reads out a quantity of attenuation of the residual image stored in the attenuation quantity storage portions in response to a time depending on the single radiographic mode or the continuous radiographic mode, and makes a switch to the read quantity of attenuation of the residual image;

a computing unit that subtracts the quantity of attenuation of the residual image switched by the second switch from a signal outputted from the X-ray flat panel detector; and

a control portion that controls the image memory, the attenuation quantity storage portions, and the first and second switches on the basis of respective signals, including control signals for each of the X-ray image acquisition modes including a radiographic signal and a fluoroscopic signal, and an image synchronizing signal to enable a display on the display means.

11. (new) The X-ray image diagnostic apparatus according to Claim 10, wherein:

the control portion determines a quantity of the residual image generated from continuous exposures in response to an exposure time in the continuous radiographic mode.

REMARKS

Applicants acknowledge the objection of claims 4-7 as being allowable if written in independent form. Claims 4-7 have been retained in dependent form at this time, since claim 1 is considered to be allowable as discussed below. However, applicants have also presented new claims 8 - 11, wherein claim 8 represents claim 4 written in independent form, claim 9 represents claim 5 written in independent form and claim 10 represents claim 6 written in independent form. Thus, claims 8 - 10 and dependent claim 11 should now be in condition for allowance.

By the above amendment, additionally, independent claim 1 has been amended to incorporate features of claim 2 therein, with claim 2 being canceled, and to clarify features of the present invention. Applicants submit that all claims should now be in condition for allowance as will be discussed below.

At the outset, Applicants note that the present invention is directed to an X-ray image diagnostic apparatus for performing residual image correction processing corresponding to the attenuation characteristic of a residual image that varies in real time. One exemplary way of achieving this can be seen in Fig. 2 and explained on pp. 11 – 13 of the specification. The image memory 10 stores an image in the fluoroscopic mode after X-ray irradiation ends in the radioscopic mode and before X-ray irradiation starts by switching to the fluoroscopic mode, that is, it stores one frame of a residual image. The image memory 10 acquires residual image data corresponding to an X-ray dose incident on the X-ray flat panel detector 4 during an exposure by storing an image after a pre-set time from the end of the exposure. The residual image

data thus acquired is stored in the image memory 10 according to a radiographic signal outputted from the X-ray generation high-voltage power source 7. The attenuation table 11 stores, as the attenuation characteristic, quantities of attenuation corresponding to the pixel positions of a fluoroscopic image immediately after an image of the residual image is stored in the image memory 10, that is, from first and subsequent frames. An exposure is performed at a specific X-ray dose in advance, and images of a residual image of plural frames are stored successively in the attenuation table 11 while X-rays are shielded, so that quantities of attenuation of these images of the residual image can be read out in response to a specific X-ray dose. This is different from the "Background Art" described in pps. 1-2, where a workstation would predict further attenuation of the residual image phenomenon on the basis of a modeled attenuation. Here, by measuring residual image data while varying an X-ray dose, it is possible to create an attenuation table corresponding to the residual image data that differs with a varied X-ray dose. Plural frames of residual image data that keeps varying can be thereby acquired according to the image synchronizing signal. The computing unit 12 subtracts the residual image data that attenuates with time as is shown in the attenuation table from a fluoroscopic image after the exposure. A fluoroscopic image from which the residual image is removed or reduced can thus be found. Applicants submit that the pending claims 1 and 3 recite such features which are not disclosed or taught in the cited art, as will become clear in the following discussion.

As to the rejection of claims 1 and 3 under 35 USC 102(b) as being anticipated by Amitami (JP 2000-175892) and the rejection of claim 2 as

being unpatentable under 35 USC 103(a) over Amitani ('892) in view of Ishikawa (JP 2003-010159); such rejections are traversed insofar as they are applicable to the present claims and reconsideration and withdrawal of the rejections are respectfully requested.

As to the requirements to support a rejection under 35 USC 102, reference is made to the decision of In re Robertson, 49 USPQ 2d 1949 (Fed. Cir. 1999), wherein the court pointed out that anticipation under 35 U.S.C. §102 requires that each and every element as set forth in the claim is found, either expressly or inherently described in a single prior art reference. As noted by the court, if the prior art reference does not expressly set forth a particular element of the claim, that reference still may anticipate if the element is "inherent" in its disclosure. To establish inherency, the extrinsic evidence "must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill." Moreover, the court pointed out that inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.

In this case, Amitani ('892) does not disclose all the elements of amended claim 1. Previously dependent claim 2 as well as the additional limitation, which is obtained in the fluoroscopic mode after X-ray irradiation ends in the radiographic mode and before X-ray irradiation starts by switching to the fluoroscopic mode, have been added to claim 1 to distinguish claim 1 from the prior art of record. Amitani ('892) does not disclose or teach the limitations of previously dependent claim 2 nor does Amitani disclose or teach

the claimed sequence of storing image memory involving fluoroscopy or radiography in the manner claimed. Applicants therefore request withdrawal of claims 1 and 3 under 35 USC 102(b).

To establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974).

Irrespective of the Examiner's comments concerning the applicability of Amitani ('892) or Ishikawa ('159) to the previous claimed invention, applicants submit that neither prior art reference teaches in the sense of 35 USC 103, the recited features of claim 1, which has incorporated previously rejected claim 2 that was rejected under 35 USC 103.

According to amended claim 1, one frame of the residual image data stored in an image memory is obtained in the fluoroscopic mode after X-ray irradiation ends in the radiographic mode and before X-ray irradiation starts by switching to the fluoroscopic mode. This one frame of the residual image data is used when a computing unit reads out the quantities of attenuation of the first and subsequent frames of the residual data.

To the contrary, Amitani discloses a device that searches for the after-image elimination property A and B based on photography conditions and they are used for predicting after-image level (residual image) as is described in sections [0051] – [0053] of Amitani. But after-image level (residual image) is influenced not only by the photography conditions but also by the object to be imaged in the radiographic mode or the pixel level in the image obtained by the radiographic mode. The disclosure of Amitani is similar to the

"Background Art" (pp. 1, 2 of original specification) where the residual image phenomenon is "modeled" and the workstation then predicts further attenuation of the residual image phenomenon.

According to the amended claim 1, one frame of the residual image data stored in an image memory is obtained in the fluoroscopic mode after X-ray irradiation ends in the radiographic mode and before X-ray irradiation starts by switching to the fluoroscopic mode. By using this one frame of the residual data, residual image data that attenuates with time after the radiographic mode can be obtained, and a residual image which is produced by the irradiation of X-ray in the radiographic mode can be removed or reduced. The residual image that is produced by the irradiation of X-ray in the radiographic mode lasts very long, about 120 to 150 sec, as described in pp. 17, lines 19-21 of the specification. The removal or reduction of this residual image is one of the exemplary objects of the claimed invention.

The secondary reference of Ishikawa ('159) does not make up for the deficiencies of Amitani. Ishikawa ('159), measures a residual image for the correction only "in an idle state during fluoroscopy," unlike amended claim 1 which measures the image for the correction in the fluoroscopic mode after X-ray irradiation ends in the radiographic mode and before X-ray irradiation starts by switching to the fluoroscopic mode. In the case of Ishikawa, the residual image that is produced by the irradiation of X-ray in the radiographic mode cannot be obtained. Because in an idle state during fluoroscopy, the residual image that is produced by the irradiation of X-ray in the radiographic mode and the residual image that is produced by the irradiation of X-ray in the fluoroscopic mode, which lasts several seconds are mixed, the residual

images cannot be distinguished from each other. Ishigawa therefore, does not teach or disclose the deficiencies of Amitani such that the removal or reduction of the residual image that is produced by the irradiation of X-ray in the radiographic mode, can be achieved.

For these reasons, applicants submit that claims 1 and 3 patentably distinguish over Amitani in view of Ishigawa, and should be considered allowable thereover. Accordingly, in addition to claims 8 - 11, which should be allowable, claims 1, 3 and 4 - 7 should also be allowable and issuance of an action of a favorable nature is requested.

To the extent necessary, Applicants petition for an extension of time under 37 CFR §1.136. Please charge any shortage in the fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account No. 01-2135 (Case No. 529.45479X00) and please credit any excess fees to such deposit account.

Respectfully submitted,

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